Jan. 30, 1968 F. R. SILEO 3,366,814

HIGH POWER RADIATION SOURCE

Filed July 19, 1965 2 Sheets-Sheet 1

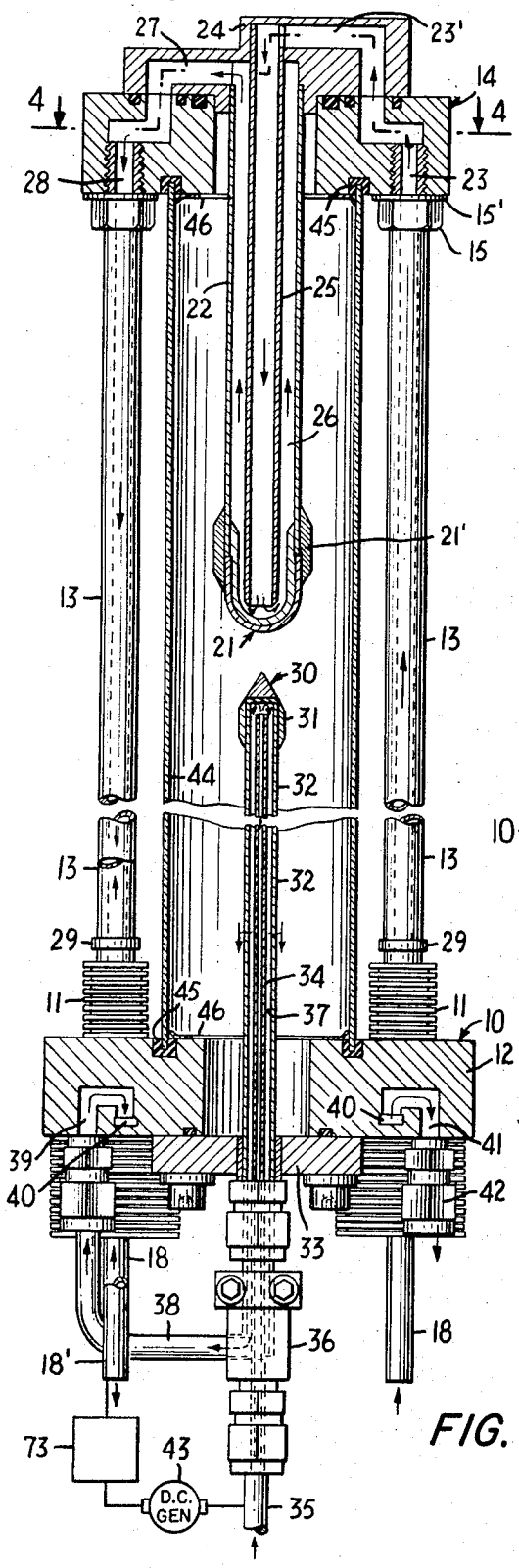


FIG. 1

FIG. 4

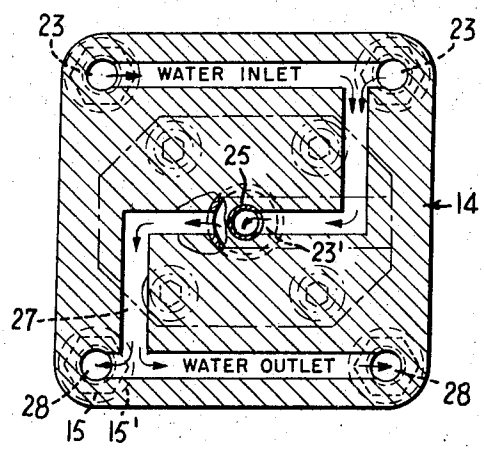
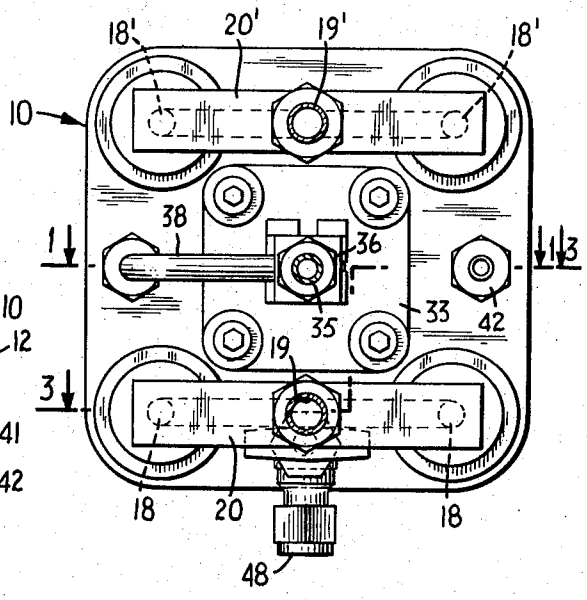


FIG. 2



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FIG. 3

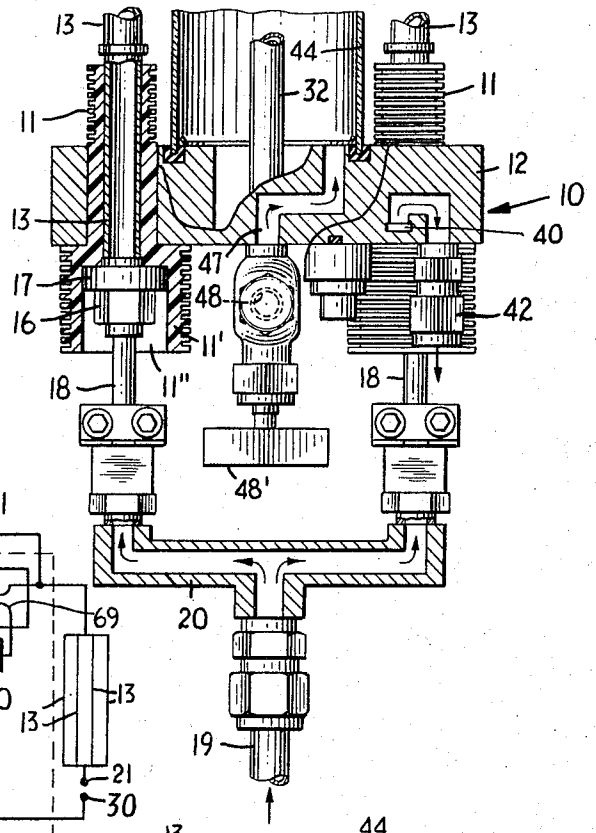


FIG. 5

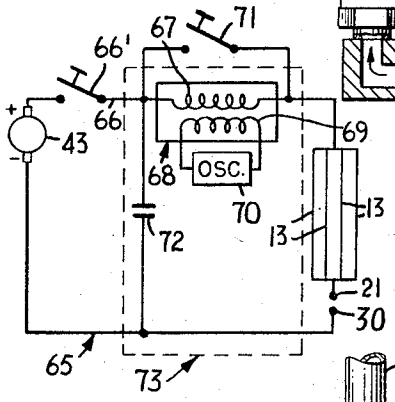
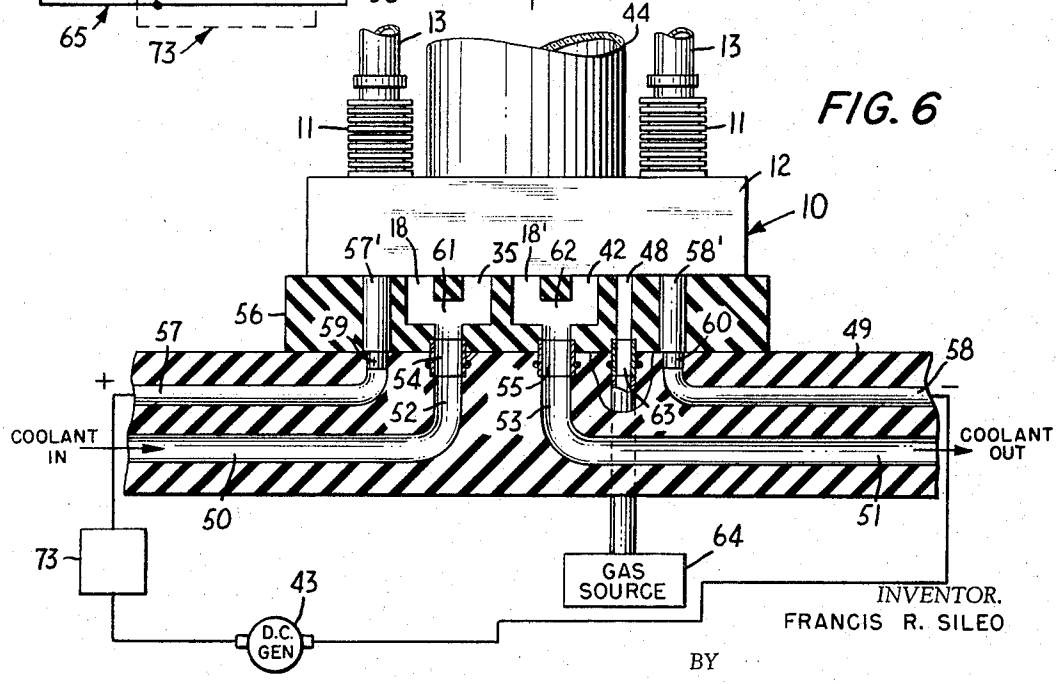


FIG. 6



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HIGH POWER RADIATION SOURCE

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13 Claims. (Cl. 313—32)

ABSTRACT OF THE DISCLOSURE

A high intensity radiation source operating on a short arc established between an axially spaced liquid cooled cathode and anode encased in a transparent envelope located between a base supporting the cathode and a top plate supporting the anode. Tie rods electrically insulated from the base join the flange and the base, the tie rods, plate and base all having internal passages through which a liquid coolant is circulated from coolant connections made through the base end of the source. An electrical source is connected between the cathode, which may be in electrical contact with the base, and the tie rods through which current is supplied to the plate and anode.

This invention relates to a high power radiation source and has particular reference to a compact, efficient, liquid-cooled and mechanically sealed electric arc apparatus of the class generally known as the short arc lamp, although its use is not so limited.

Short arc lamps have been long known and used, but they are expensive to make, maintain and use and complicated in structure. Particularly is this the case with sealed arc lamps operating in a high pressure atmosphere of a gas which is capable of being rendered luminescent in an electrical discharge such as an electric arc.

In accordance with this invention a high power radiation source is provided in the form of a compact mechanically sealed unit entirely mounted at one end on a single base having supply and discharge ducts for circulating a coolant through jackets enclosing the anode and cathode which are sealed within a transparent envelope to which is supplied through the base a gas under pressure.

More particularly, the structure of the high power radiation source of this invention includes four hollow tie rods mounted on the common base and serving the dual purpose of energizing the anode and supporting the upper or anode end of the apparatus and supplying to and discharging therefrom the anode coolant through passages in the upper or anode end connected to and from the aforementioned hollow tie rods. The coolant from a common source is circulated through the cathode from and back to passages in the base. The transparent envelope enclosing the anode and the cathode and mechanically sealed gas tight between the base and the upper or anode end by the tie rods is adapted to be filled through a valve with a gas capable of being rendered luminescent by an electrical arc discharge. The arc is struck without moving the electrodes according to the present invention.

In a preferred form the apparatus of this invention is conveniently adapted for rapid connect and disconnect enplacement by suitable fittings cooperating with electrical conductors and coolant and gas conduits mounted within a fixed plate or rail cooperating with the coolant supply and discharge pipes and the gas supply and electrical connections carried by the common base of the apparatus, so that it may be mounted and dismounted to and from the plate or rail at will and moved about as a self-contained mobile unit.

For a more complete understanding of the invention,

reference may be had to the accompanying drawings, in which

FIGURE 1 is an axial section through the high power radiation source apparatus of this invention as seen along the line 1—1 of FIG. 2;

FIG. 2 is a bottom view of the base of the apparatus of FIG. 1 showing the anode and cathode electrical connectors and their coolant inlets and outlets as collectively mounted in the base of the apparatus;

FIG. 3 is an axial section through the base of the apparatus as seen along the line 3—3 of FIG. 2 and showing the anode coolant supply and the gas envelope filling pipe;

FIG. 4 is a transverse cross-section through the top plate as seen along the line 4—4 of FIG. 1 and showing the coolant passages leading to and from the depending anode and to and from the tubular tie rods supporting the top plate;

FIG. 5 is a diagram of the electrical system for the high power radiation source of this invention, and showing particularly the starting circuitry thereof; and

FIG. 6 shows a vertical section through a quick plug-in connecting and disconnecting arrangement for rapidly mounting and dismounting the apparatus on a rail or table equipped with receiving sockets for such plugs and containing coolant supply and discharge pipes and electrical connectors as well as a gas supply.

Referring to the drawings, numeral **10** designates the base mounting the entire apparatus and comprising cathode flange **12** of copper or other material having a high thermal conductivity. Cathode flange **12** constitutes the major portion of the base **10** and is generally square in shape as shown in FIG. 2. Mounted at the corners of the cathode flange **12** are four tubular slotted high voltage radio frequency insulators **11** passing through corresponding apertures in the cathode flange **12** and each having an enlarged lower end **11'** forming shoulders which abut the under surface of the cathode flange **12** and contain an enlarged axial bottom socket **11''**, as particularly shown in FIG. 3.

Passing upwardly through each insulator **11** and mounted therein is a tubular one-piece tie rod **13**, preferably of stainless steel and serving the purposes of electrical and coolant conductor and as supporting tie rods for the square upper or anode flange **14** of copper or other material having a high thermal conductivity. The upper end of each tie rod **13** is threaded and screwed into a corresponding tapped hole in the anode flange **14**. A hexagonal nut **15** secured to the upper end of each rod **13** enables the rod to be screwed securely over sealing washer **15'** into the anode flange **14** as shown in FIG. 1.

A nut **16** screwed into the threaded lower end of each tie rod **13** over stainless steel bearing washer **17** abutting the shoulder in insulator socket **11''** serves to securely clamp the cathode and anode flanges **12** and **14**, respectively, together through the four tie rods **13**, as is shown in FIG. 3. Nut **16** also couples to the lower end of the corresponding one-piece tie rod **13** having a reduced lower extension **18** which serves the purpose of conducting coolant to and from anode flange **14** through two of the connected tubular tie rods **13** from the coolant source pipe **19** and branch coupling **20**, as shown in FIG. 3. In addition to serving as coolant conduits, tubes **18**, **18'**, **19**, **19'**, **20** and **20'** serve as conductors of high density direct current to the anode **21** through tie rods **13**, anode flange **14**, anode tube **22** to the anode **21** to be described.

As shown in the partial axial section of FIG. 3 and also FIG. 1, the anode electrical connector supply pipe **19** also serves as coolant supply to the anode **21** through **20**, **18** and two of the tubular tie rods **13** to the passages **23** and **23'** in anode flange **14** and head **24** of copper or other material having a high thermal conductivity. The

passages 23 are best shown in FIG. 4 taken with FIG. 1 as receiving coolant from two tie rods 13 which in turn receive coolant from anode coolant inlet 19 (FIG. 3). The passage 23' aligned with passages 23 in head 24 supplies coolant to the interior of coolant tube 25 extending downwardly through closed end copper anode support tube 22 to the anode 21 carried by said tube 22 secured to the head 24, as shown in FIG. 1. Anode 21 is preferably formed of tungsten or its equivalent and carries and is shielded by tantalum anode shield 21' shown in FIG. 1.

After passing through the tube 25 to the tip of anode 21 the coolant then passes upwardly through the annular space 26 between inner tube 25 and outer tube 22 back to the anode flange 14 into the outlet passage 27 in head 24 to discharge through passages 28 into the other two tie rods 13 for discharge through connections 19' shown in FIG. 2 and corresponding to those shown in FIG. 3 except that they are mounted on the opposite side of the base and the flow is reversed.

Axially aligned with anode 21 and closely spaced therefrom is the upwardly extending cathode 30, preferably comprising thoriated tungsten and having a tantalum shield 31, both brazed to the upper closed end of cathode support tube 32, preferably made of copper and mounted at its lower end in copper plate 33 bolted and sealed to the under surface of cathode flange 12 as best shown in FIG. 1. Cathode support tube 32 contains concentric coolant inflow tube 34 connected to cathode coolant supply tube 35 suported by branch coupling 36 carried by the plate 33.

The annular space 37 between concentric tubes 32 and 34 is connected through a cathode branch coupling 36 to lateral conduit 38, feeding coolant from annular cathode space 37 through duct, or passage, 39 to one side of a circular coolant channel 40 formed in cathode flange 12 to cool the same and discharge at its other side through passage 41 to coolant discharge outlet fitting 42. The negative terminal of the direct current source such as generator 43 is connected to cathode coolant supply tube 35 in electrical contact with the cathode support tube 32, with the positive terminal of generator 43 connected to coolant extension 18 of each of the unitary tie rods 13, one of such connections being shown diagrammatically in FIG. 1. By supplying current to all four tie rods 13, as shown schematically in FIG. 5, the arc is magnetically stabilized. Thus, if current were supplied to only one tie rod 13, the resulting magnetic field established around that tie rod would repel the arc away from the energized tie rod and thus render the arc unstable. With all four energized tie rods 13 symmetrically arranged about the axis of the arc, their induced magnetic field is a minimum at the axis of the arc. This balancing method is adaptable to structures utilizing two, three, four or more energized tie rods.

Clamped between cathode flange plate 12 and anode flange plate 14 by the four tie rods 13 is a clear quartz tube 44 axially enclosing aligned anode 21 and cathode 30 and mechanically sealed at its opposite ends in gaskets 45 seated in corresponding circular channels in cathode plate 12 and anode plate 14. Gaskets 45 are shielded from radiant energy and hot gases by tantalum shields 46 at each end of quartz tube 44. The transparent envelope so formed is filled under pressure with a gas capable of being rendered luminescent in an electric discharge. Suitable gases are xenon, argon, krypton and the like or mixtures thereof, and are introduced into the envelope 44 through passage 47 in cathode flange 12 and connected to gas inlet pipe 48 controlled by a hand valve 48', as shown in FIG. 3. A stainless steel collar 29 near the lower ends of each rod 13 precludes a short circuit between the anode and cathode in case of violent failure of envelope 44.

The electrical system for the high power radiation source of this invention as depicted diagrammatically in FIG. 5 includes the aforementioned direct current generator 43 or an equivalent direct current source, whose negative terminal is connected by conductor 65 across the cathode 30 and anode 21 gap through the four tie rods 13 and one terminal of secondary winding 67 of a high voltage step-up pulse transformer 68 capable of carrying minimum arc current. The other terminal of secondary winding 67 is connected by conductor 66 through switch 66' to the positive terminal of generator 43. The primary winding 69 of transformer 68 is energized by a conventional spark gap type oscillator 70. Bridged across the transformer 68 is a normally open high current by-pass switch 71 with a low inductance by-pass capacitor 72 connected across conductors 65 and 66. The starting circuitry for the system includes the elements 68, 70, 71 and 72 shown in FIG. 5 and preferably is mounted in the direct current line from the generator 43 and as close as possible to the apparatus as shown in FIG. 1 so as to minimize radio frequency losses.

As will have been observed, all of the elements of the apparatus of this invention are carried by the base 10 and all of the inlet and outlet supply lines are mounted in and connected through the base 10, so that the entire apparatus may be connected to and disconnected from a common supply bracket or rail by plug-in connectors and thus the entire apparatus may be moved about at will to other locations. Hence, as shown schematically in the support unit of FIG. 6, an insulating supply bracket, table top, or rail 49 contains coolant supply and discharge passages 50 and 51, respectively, leading to corresponding sockets 52 and 53 connectible by snap-in plugs 54 and 55, respectively, carried by a plate 56. Similarly, bracket or rail 49 contains electrical conductors 57 and 58 connected to opposite terminals of the direct current generator 43 and terminating at their other ends in corresponding sockets for receiving respective snap-in plugs 59 and 60 carried by plate 56.

Plate 56, of electrical insulating material, carrries the supporting base 10 and the apparatus of this invention. The coolant inlets 18 and 35 and outlets 18' and 42 of the apparatus are connected to branched passages 61 and 62, respectively, whereas the electrical connector plugs 59 and 60 are connected to leads 57' and 58' in plate 56 in turn connected to conductors 18, 18' and 35 of the apparatus base 10. Similarly, a socket 63 in plate 56 is connected to gas supply source 64 and is adapted to receive a snap-in plug leading to gas inlet pipe 48 in the apparatus. The gas shut off valve 48' (FIG. 3) from supply source 64 is not shown in FIG. 6 but is part of the apparatus as shown in FIG. 3 to prevent loss of gas when the apparatus including base 10 is to be disconnected from the rail 49 of FIG. 6, as described. These plugs in plate 56 for receiving coolant supply and discharge, electrical positive and negative supply and envelope gas are aligned with corresponding sockets in rail 49 for quick connect and disconnect of the entire apparatus to and from rail 49 in the manner described.

The operation of the high power radiation apparatus of this invention will be readily understood from the foregoing description and is placed into operation by closing switch 66' so that the resulting direct current voltage from generator 43 appears across the anode-cathode gap 21, 30. The starter 73 is then energized through transformers 68, causing a high voltage on the order of 40 to 50 kilovolts of radio frequency potential to be impressed across the anode-cathode gap 21, 30 in addition to the open circuit direct current voltage of generator 43. This high voltage across the anode-cathode gap 21, 30 is sufficient to initiate ionization of the gas in envelope 44, e.g. xenon, between the anode 21 and cathode 30, so that the unit can draw from generator 43 the minimum current necessary for its operation within a fraction of a second. When the arc strikes, high current by-pass switch 71 is closed and the starter 73 is deenergized. The arc unit is supplied with full operating current and the arc is sustained. The low inductance by-pass capacitor 72 in the

starting circuitry **73** prevents high voltage damage to the generator **43**.

This starting sequence results in striking the arc between the anode **21** and the cathode **30** and incandescent illumination of the gas within the quartz envelope **44**.

This starting system makes unnecessary bringing the anode and cathode into contact, or close to contact, in order to initiate the current flow and then separating them to draw the arc. Hence the anode and cathode are and remain properly spaced to effect the most efficient operation of the apparatus without further adjustment.

It will be seen that the high power radiation apparatus of this invention is a self-contained unit, being entirely carried by a single base **10** which contains the coolant supply and discharge ducts, the gas supply pipe and shut-off valve, and the electrical connections. The mechanical seals are readily opened and closed with ease for cleaning and replacing of the quartz envelope and internal parts and the single-ended supporting and connecting devices enable the entire unit to be moved about and readily connected and disconnected at will. This mobility permits emplacement at numerous locations by quick connect and disconnect devices joining the various coolant inlets and outlets and the gas and electrical connections to be made to a rail or table containing cooperating connections in the manner described in connection with FIG. 6. The facility with which the apparatus of this invention may be used and constructed provides high power levels, mechanical rather than hermetic seals and low cost of manufacture and operation.

Although a preferred embodiment of this invention has been illustrated and described herein, it is to be understood that the invention is not limited thereby but is susceptible of changes in form and detail within the scope of the appended claims.

I claim:

1. A high power radiation apparatus comprising a unitary mounting base through which operative connections are established for operation of the apparatus, said base having inlet and outlet coolant passages therethrough, a radiation transmitting envelope mounted on said base, said base providing a closure for said envelope, spaced electrodes positioned within said envelope and supported on said base, electric power connection means to said electrodes through said base, each said electrode having a passage for circulating coolant therethrough, and coolant conveying means for connecting each said electrode cooling passage through the passages of said base.

2. Apparatus according to claim **1** in which the operative connections through the unitary mounting base comprise means for supplying gas under pressure to the interior of the envelope.

3. A high power radiation apparatus comprising a base having passages therethrough, radiation transmitting envelope mounted on said base, a pair of spaced electrodes positioned within said envelope, each having an internal coolant passage therein, at least two tubular tie rods supported on said base, a source of electric power connected to one of said electrodes through said base and to the other of said electrodes through said base and tie rods, and means for conveying cooling fluid to the internal passage of the one electrode through a passage in said base and to the internal passage of the other electrode through a passage in said base and at least one of said tie rods.

4. A high power radiation apparatus comprising a base, a first electrode mounted on the base, a second electrode spaced from the first electrode, each electrode having a cooling passage therein, at least two tie rods supported on the base, at least one of the tie rods having a passage therein, means supporting the second electrode on the tie rods and providing a conduit between the tie rod passage and the cooling passage of the second electrode, means for connecting a cooling fluid source to the tie rod passage and to the passage of the first electrode, means for connecting a source of electric power to the second electrode through the base, supporting means and tie rods, and a sealed radiation-transmitting envelope supported on the base enclosing the electrodes.

5. A high power radiation apparatus comprising a base, a first electrode mounted on the base, a second electrode spaced from the first electrode, each of the electrodes having a cooling passage therein, at least two tie rods supported on the base and providing coolant passages therethrough, means for connecting a fluid supply source to one of the tie rods, means supporting the second electrode on the tie rods and including a coolant inlet path between the passage of the one tie rod and the cooling passage of one of the electrodes, the supporting means further providing a cooling fluid discharge path between the last-named electrode passage and the passage in the other tie rod, means for connecting a source of electric power to the first and second electrodes through the base and a sealed envelope supported on the base and enclosing the electrodes.

6. A high power radiation apparatus comprising a base, a first electrode mounted on the base, a second electrode spaced from the first electrode, each of the electrodes having a passage for circulating a coolant therethrough, at least two tubular tie rods supported on the base, means for coupling a coolant fluid supply source to one of the tie rods, means supporting the second electrode from the tie rods and providing (a) a fluid inlet path between the one tie rod and the coolant passage of the second electrode and (b) a coolant fluid discharge path between the second electrode passage and the other tie rod, means providing a discharge path through the base for fluid coolant from the other tie rod, and means for connecting a source of electric power between the first and second electrodes through the base, and a sealed radiation-transmitting envelope supported on the base and enclosing the electrodes.

7. A high power radiation apparatus comprising a base, a first electrode mounted on the base, a second electrode spaced from the second electrode, each electrode having a passage for circulating coolant therethrough, at least two hollow tie rods supported on the base, a top plate secured to the tie rods and carrying the second electrode, the top plate having passages therein communicating with the hollow tie rods and second electrode passage, means for connecting a source of coolant to one of the hollow tie rods through the base to establish coolant flow through the top plate passage and the coolant passage of the second electrode, means for connecting a source of electric power to the first electrode through the base and to the second electrode through the base and tie rods, and a sealed envelope supported on the base and enclosing the electrodes.

8. A high power radiation apparatus comprising a base having passages, a first electrode mounted on the base, a second electrode spaced from the first electrode, each electrode having a passage for circulating coolant therethrough, means carrying the second electrode including at least two hollow tie rods secured to the base to provide interconnecting passages between the base passages and the second electrode passage, means for connecting a source of coolant through the base passages to establish coolant flow through the passage of the second electrode, means for connecting the coolant source through the base to establish coolant flow through the passage of the first electrode, means for connecting a source of electric power to the first electrode through the base and to the second electrode through the base and tie rods, and a sealed radiation-transmitting envelope enclosing the electrodes.

9. A high power radiation apparatus comprising a base having passages therethrough, a first electrode mounted on the base and having a coolant passage therethrough communicating with one of the base passages, a second electrode spaced from the second electrode and having a coolant passage therethrough, means including at least one tie rod in electrical contact with and supporting the second electrode on the base, the tie rod providing a coolant path between the coolant passage in the second electrode and

another of the passages in the base, a sealed envelope carried by the base and enclosing the electrodes, a support unit for the base containing coolant supply and discharge conduits and providing separate electrical paths therethrough to the first electrode and tie rod, respectively, and separable connectors between the conduits in the support unit and the coresponding passages in the base for connecting coolant and electrical sources to the electrodes through the support unit and base.

10. A high power radiation apparatus comprising a base having a supply passage therethrough, a first electrode mounted on the base, a second electrode spaced from the first electrode, each electrode having a coolant passage therethrough, at least two tie rods supported on the base, one of the tie rods being tubular, means secured to the one tie rod and carrying the second electrode, said means providing (a) an electrical connection between the tie rod and the second electrode and (b) a coolant conduit between the one tie rod and second electrode passage, a sealed envelope supported on the base and enclosing the electrodes, a support unit for the base containing a coolant supply conduit and providing electrical paths therethrough to the first electrode and the one tie rod, and separable connectors between the conduit in the support unit and the corresponding supply passage in the base for connecting coolant and electrical sources to the electrodes through the support unit and base.

11. A high power radiation apparatus according to claim **10**, in which the base and support unit provide a gas supply passage communicating with the interior of the envelope, the apparatus further comprising a separable connector in the gas supply pasage between the base and support unit for connecting a source of gas to the interior of the envelope through the base and support unit.

12. A high power radiation apparatus comprising a base having coolant inlet and discharge passages therethrough, a first electrode mounted on the base, a second electrode spaced from the first electrode and including a coolant passage, a top plate having coolant inlet and discharge passageways therethrough communicating with the second electrode passage, at least two tie rods supporting the top plate on the base and providing conduit paths communicating with the passageways in the top plate and the corresponding passages in the base to provide coolant inlet and discharge paths through the base to the second electrode, and a sealed radiation-transmitting envelope disposed between said tie rods intermediate the base and top plate and enclosing the electrodes.

13. Apparatus as defined in claim **12**, in which the base includes a further passage therethrough communicating with the interior of the envelope.

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JAMES W. LAWRENCE, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,366,814 January 30, 1968

Francis R. Sileo

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 54, before "radiation" insert -- a --; column 6, line 32, strike out "and"; lines 38 and 71, for "second", each occurrence, read -- first --.

Signed and sealed this 22nd day of April 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents